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QUANTITATIVE STUDIES OF SURFACE CATCHES OF MARINE DIATOMS AND DINOFLAGELLATES

TAKEN IN ALASKAN WATERS BY THE INTERNATIONAL FISHERIES COMMISSION IN THE FALL AND WINTER OF 1927-1928 AND 1929

BY

WINFRED EMORY ALLEN

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THE CRUISES OF 1927–1928

Introduction

The surface catches constituting these series were all taken in connection with cruises for halibut investigations under direction of Will F. Thompson, Director of Investigations of the International Fisheries Commission. Three cruises were made, one each in November and December of 1927, and one in January of 1928. The first was through the "inside passage" from Seattle to Cape Spencer and across the Gulf of Alaska to a point southwest of Middleton Island. The second was similar except for going only about one hundred miles north of west of Cape Spencer. The third differed principally through including seaward runs from Ocean Cape, from Cape Cleare, and from Cape Chiniak to distances of fifty-five to seventy-four miles offshore. The territory covered was nearly the same as that traversed by the U. S. Coast and Geodetic Survey ship "Pioneer" in April of 1923 (Allen 1927) and 1924 when it made similar catches at the surface of the sea.

All catches of the series covered by this report were made by obtaining five liters of water with the Allen Closing Bottle (Allen 1927*b*) and filtering it through a small net of No. 25 silk bolting cloth (average diameter of openings about .05 millimeter). Enumeration of diatoms and dinoflagellates in one four-hundredth of each catch was made by use under the microscope of a Sedgwick-Rafter counting cell and Whipple micrometer, and the numbers per liter were estimated, all according to standard methods of the Scripps Institution of Oceanography.

Dinoflagellates

Species—

Four genera of dinoflagellates were represented by nine recognized species and two unidentified forms. *Ceratium* was represented by seven species in thirteen catches, but no two of these were observed in any catch. *C. longipes* (Bail.) was found in four catches, but no other species was observed in more than two. The other species recorded were *C. candelabrum* (Ehr.), *C. furca* (Ehr.), *C. fusus* (Ehr.), *C. kofoidii* Jörg., *C. pentagonum* Gour., and *C. tripos* (O. F. M.).

Challengeria was represented by a specimen of an unidentified species in one catch, and *Dinophysis* was once represented by *D. caudata* Kent.

Peridinium was represented by *P. divergens* Ehr. in one catch and by specimens of unidentified species in three other catches.

Of the nine species identified, *Ceratium longipes* (Bail.) is the only one appearing to belong especially to higher latitudes. Nearly all of the other species named are commonly and frequently found off and along the coast of Southern California. However, all of the different specimens seemed to be in good condition, and the only evidence of the environment being more favorable for *C. longipes* lay in its being caught at more stations.

Numbers—

All the catches of dinoflagellates were very small, only one or two specimens being found in the fraction of any catch examined. In connection with the low frequency (about one in ten) of catches yielding dinoflagellates in these series, such numbers give strong indication that in Alaskan waters (as well as in other localities) the late fall and the winter constitute a period very unfavorable for dinoflagellate growth and development, although the healthy appearance of the observed specimens gives equally good indication that conditions are not directly injurious.

Diatoms

Genera and species—

In spite of the unfavorable season of the year and the rather small size of the samples, diatoms were found in more than two-thirds of the catches (in ninety-three out of one hundred and thirty-four). Furthermore, there was found a considerable number of different species (thirty) and unidentified forms representing sixteen genera. Eighteen species and unidentified forms representing ten genera were listed in more than one catch (table 1). Twenty species belonging to eleven genera were recorded in the November series, fourteen species belonging to ten genera in the December series, and seventeen species belonging to eleven genera in the January series.

With very few exceptions the specimens of diatoms appeared to be in excellent condition. From the fact that so many species were found represented by normal or vigorous individuals one may infer that general conditions of maintenance are tolerable in the fall and winter seasons in Alaskan waters, and that increase of abundance waited upon increase of appropriate stimuli and shift of inactive conditions rather than upon decrease of directly injurious influences which might be supposed to be present.

The continuation of occurrence of several prominent species through the three months (table 1) shows also that in that time no important alteration occurred in the conditions governing existence of diatoms in that area. In other words, the plants of the marine

plankton may respond to the approach of winter like plants of the land by going into a relatively inactive stage of existence through which their health and vigor remain unimpaired.

On the other hand, it seems fairly clear that certain prominent genera (table 1) are affected differently by the onset of winter. Although *Chaetoceras* was prominent in November, it was rarely seen in December and was almost missing in January. The same was true of *Thalassiothrix,* but the reverse was true of *Thalassiosira.* These differences suggest the possibility of a seasonal periodicity, *Chaetoceras* and *Thalassiothrix* tending to disappear in winter when *Thalassiosira* is getting ready for an early efflorescence at the end of winter.

TABLE 1

Phytoplankton. Thompson—Alaska, 1927–1928

Species of Diatoms Recorded in More than One Catch

Name	Number of times recorded			
	November	December	January	Total
Chaetoceras atlanticum Cl	5			5
debile Cl	2			2
decipiens Cl	1		1	2
densum Cl	10	3		13
species	13	3	1	16
Coscinodiscus excentricus Ehr.		1	8	9
radiatus Ehr.	2		2	4
sp.	13	14	12	39
Ditylum brightwellii (West.)	1	3	2	6
Navicula sp.	4			4
Nitzschia longissima (Breb.)	3			3
Skeletonema costatum (Grev.)	1	1	3	5
Stephanopyxis turris (Grev.)	1	1	1	3
Thalassiosira decipiens (Grun.)		3	7	10
rotula Meun.	1		1	2
Thalassiothrix longissma Grun. & Cl.	12	1	1	14
nitzschioides Grun.	11	4	2	17

All of the species recorded have been found as far south as California, but all of the species of *Thalassiosira* have been more frequently found, and found in greater abundance, in northerly waters. *Ditylum brightwellii* (West) was much smaller and its shape somewhat different from that shown usually in California localities. This is contrary to the showing of many other species which appear to be more, rather than less, robust in northerly waters. None of the species listed in table 1, however, were noticeably different in appearance as compared with those observed elsewhere.

Numbers—

All the catches of diatoms were very small, only one being estimated at more than two thousand cells to the liter, and the number in this depended upon a single large colony. The numbers of individual cells agreed with the number of species in being slightly larger in November than in the other two months. It also appeared that numbers were slightly greater offshore in the Gulf of Alaska than they were at the inshore and channel stations. In dealing with such small numbers, however, it is not permissible to attach much importance to this last point as evidence until it can be followed through many more catches distributed over several seasons or years.

Because of the fact that the "Pioneer" catches had been very large at certain stations in April of two years, notably in Chatham Strait and the region of Cape Spencer, special care was taken to get winter catches near those points. Some of these catches yielded no diatoms and all were comparatively light, even for these series. These results give strong indication that during a poorly productive period highly productive regions are not distinguishable from poorly productive regions. All tend to resemble each other in their poverty.

THE CRUISE OF 1929

Plankton catches were taken on only one cruise by the International Fisheries Commission in the winter of 1928–1929. This cruise extended from January 10 to February 24, 1929, and it covered most of the territory covered by the cruises of 1927–1928. The catches were made in the same way and subsequent examination of the material was made by similar methods.

For this cruise the sixty-eight catches made after reaching the Gulf of Alaska may be conveniently grouped into seven series. In chronological order these were (1) from Cape Spencer to fifty miles west, (2) from Ocean Cape to two hundred and twenty-four miles south, (3) from Cape Cleare to two hundred and thirty miles southeast, (4) from Pilot Rock to sixty-one miles partly west of south, (5) from Cape Chiniak to one hundred and fifty-five miles southeast, (6) from Marmot Island to one hundred and five miles nearly northeast, (7) from one hundred and forty-four miles south to Ocean Cape. On both outward and homeward parts of the cruise, catches to the number of forty were taken at certain stations in the "inside passage" where collecting had been done on former cruises.

Dinoflagellates

In only nine catches out of one hundred and eight were dinoflagellates represented in 1929. Six of these catches were in the Gulf of Alaska and three in the "inside passage," and in each case only one specimen was observed in the fraction of the catch examined. *Ceratium longipes* (Bail.) was found in four of the Gulf catches, an undetermined species of *Peridinium* and *Prorocentrum micans* (Ehr.) in the other two. *Ceratium fusus* (Ehr.) was found at one station in the "inside passage" and *Prorocentrum micans* at the other two. Except for the fact that all of these specimens appeared to be in vigorous condition, one might conclude that these latitudes were distinctly unfavorable for dinoflagellates. And it is remarkable that no large catch of dinoflagellates has appeared in several hundred catches taken in Alaskan waters in different years and in different seasons of the year (Allen 1927 and 1929). At any rate, it seems clear that the larger dinoflagellates rarely contribute notably to the plankton populations of Alaskan surface waters.

Diatoms

In only forty-nine catches out of one hundred and eight were any diatoms observed, and in only two of these were the numbers as large as five hundred cells to the liter. In most of the forty-nine catches only one or two occurrences of one or two species were recorded. Except for the two large catches near the end of the cruise and near the end of February, there was no definite indication that locations near shore or far from shore were either more or less favorable as compared with each other. Nor was there dependable evidence that one section of coast line was more favorable than another. Like the winter series of the preceding year (discussed in preceding pages of this paper), the general indication was that small numbers were due primarily to the aggregation of influences peculiar to the winter season, and that they involved lack of adequate sustenance and stimulation to propagation rather than seasonal operation of immediately injurious influences.

The outstanding feature of this 1929 series was the fairly large catch near Mary Island in Revillagigedo Channel on February 23, in which over 40,000 cells to the liter were found. Catches notably large had been obtained here by the U. S. Coast and Geodetic Survey steamer "Pioneer" in April of both 1923 and 1924, but winter catches by the International Fisheries Commission in 1927–28 and while outward bound in 1929 had been extremely low in this locality. These

differences constitute strong indication that the Mary Island locality is richly or poorly productive according to season in about the same way that more southerly localities have been found to be (Allen 1928). It seems probable that this larger catch in February represented the beginning of a productive season which may have reached a maximum in March or April, as happens so often elsewhere. *Eucampia zoodiacus* Ehr. was the leading species in this large catch, a point of considerable interest in itself because this species has been prominent in only one or two of our several hundred catches from Alaskan waters.

Aside from the relatively large catch near Mary Island and one about one-sixth as large near Pointer Island (near the northeast corner of Hunter Island), the showing of the 1929 series was essentially similar to those of 1928–1929, as stated in the preceding pages.

PHYSICAL CONDITIONS

Temperature

Temperatures recorded at the time of making the catches in 1927–28 did not range lower than they did in the April catches of earlier years made by the "Pioneer." The lowest was slightly over 39° F in both cases, and in 1923 a catch of over 350,000 cells per liter was taken where the temperature was 39.4° F (see Allen 1927, p. 46). In 1929 two stations showed temperatures a little less. This comparison shows positively that low temperature is not the factor which causes low production in winter, and that temperature may range widely without showing definitely traceable influence on numbers, according to existing sources and conditions of information. Probably all well informed biologists will agree that if lag and other confusing features of observation could be eliminated, influence of temperature might be traceable.

Salinity

The outstanding feature of salinity records for this series is the relatively low showing near shore (mostly near thirty-two parts per thousand) and the gradual increase to higher records (over thirty-four parts per thousand) during the runs into the open sea. Experience with salinity in other localities, however, shows that, like temperature, its influences on plankton production are not clearly separable from other influences in the sea. Furthermore, in dealing with such small numbers in widely different localities, it is not probable that direct influence can be traced accurately, even where an

extreme point of range is reached, because in very thin populations the errors of sampling tend to overshadow all others in attempts to compare particular catches.

Light

It is commonly known that winter in the Alaskan region is the season of short days, but it is probable that few persons stop to consider seriously the effect of this condition on living things. The mere shortening of the period of exposure to light in each day is important, as is shown well by the use of artificial light to prolong the period of exposure in commercial exploitation of certain kinds of domestic plants and animals. But in high latitudes the greater obliquity of the light rays of winter must also have great importance, especially to water-dwelling organisms whose habitat is only slightly penetrable to the very oblique rays of such latitudes. In addition (as specifically indicated by W. F. Thompson in a letter concerning the conditions of operation when obtaining these series), winter is the season of clouds and storm, of fog and rain, and of rough seas, all conditions opposed to the penetration of light.

By use of such common knowledge, it is possible, in spite of lack of quantitative observations on distribution of light, to reach certain valid conclusions, the most important of which is that feeble lighting is probably the most direct cause of poor production in the winter season.

Turbulence

When all catches are extremely light there is no opportunity to observe the influence of movements of small masses of water, even if they be fully recognized and traced. Still it may be supposed that the violent agitation characteristic of winter not only deters production by helping to obstruct light, but that it also has some direct effect through rapidly changing the positions of organisms with reference to both beneficial and detrimental materials. Especially would such movement be effective in preventing development from a focal center such as appears in cultures and often also in quiet waters. This is particularly true of vertical movements by which the relation to light would be greatly changed in very slight shifts of level of a water mass and its included organisms.

BIOLOGIC CONDITIONS

As in the case of several other groups of environmental characters already mentioned too little is known about general or specific biologic conditions to establish direct connection with features of distribution of diatoms and dinoflagellates at this period. Nothing

is known as to the possibility that animals may have been partly responsible for small numbers by decimating attacks for food in the fall, and nothing is known as to the extent to which the vigor of existent specimens may have been caused by increase in diffusion of products of animal metabolism through the turbulence of winter. With such great gaps in the chains of evidence it is impossible to trace the more remote relationship to larger animals, and particularly to fishes. Before such relationships may be brought within the bounds of practical knowledge a great deal of work must be done on the direct relationships of a number of different kinds of organisms.

GEOGRAPHIC AND TOPOGRAPHIC CONDITIONS

Since the numbers of diatoms and dinoflagellates encountered in these series were entirely too small to use in attempts at interpretations of distribution according to geographic and topographic characters, I introduce this heading mainly as a reminder that it is too important to be ignored. But there is this point of considerable value: that inshore and offshore, shallower and deeper, richer and poorer waters were all so strongly affected by the seasonal characters that they were reduced to a common monotony of resemblance in supporting extremely small numbers of robust specimens.

METEOROLOGIC CONDITIONS

It seems obvious that the relation of meteorologic conditions to distribution of light (through cloud and fog and through increasing turbulence of wind and wave) would so far outrank any other means of meteorologic influence at this season that it would be pointless to say more than has been said already in discussing light, where special emphasis has been placed on turbulence in connection with obliquity of light rays and with shortness of winter days. On the other hand, there is so much that is unknown concerning the influences of meteorologic conditions on marine life that it is desirable to push such investigations whenever and wherever possible.

COMPARISON WITH SCOTCH CAP STATION

During the time covered by all cruises discussed in this report, daily catches were taken by similar methods from the rocks at Scotch Cap Light on Unimak Island in the Aleutian Chain. Although Scotch Cap is at a considerably lower latitude than most of the stations used

on the cruises, it is far enough north to have a fairly good general resemblance in the matter of ocean temperatures and major seasonal conditions in the ocean.

Manuscript records of daily catches in the years 1927 and 1928 show distinctly that Scotch Cap is capable of good production at certain seasons (for example, five weeks in the hundreds of thousands of cells per liter through April, 1927) but they also show that abundance was low in the months in which the material for this report was collected, the maximum weekly average in November, 1927, being 660 cells per liter; in December, 1927, 440 cells; in January, 1928, 605 cells; in January, 1929, 1925 cells; and in February, 1929, 2310 cells per liter. This small range of numbers at the Scotch Cap station, where the littoral diatoms torn adrift by the surf would help to keep a fairly constant representation of these organisms in plankton catches, agrees substantially with the showing of the catches made on the cruises in indicating low abundance for the general region of the Gulf of Alaska at the surface level in winter. From such conditions one may assume that low abundance in such latitudes is due to general seasonal influences which operate there in or to an extent similar to that already known for many other regions.

SUMMARY

1. According to expectations derived from investigations in other localities, the surface catches of diatoms and dinoflagellates in Alaskan waters by the International Fisheries Commission and at Scotch Cap in November, December, and January were all extremely light. Judging from an experience in the Southern California region, however, where maximum numbers for the year were found in November (Allen 1928) it may be that numbers in Alaskan waters are sometimes larger in November and December than is indicated by these records.

2. Since no subsurface catches were taken there is no evidence to show either the presence or absence of these organisms below the surface.

3. The presence of robust representatives of large number of genera and species at numerous points in the Alaskan region, both inshore and offshore, indicates good conditions for survival and maintenance, if not for propagation.

4. Localities known to have yielded heavy catches in other seasons of other years were no more productive than other localities, with the exception of Mary Island and Pointer Island in February, 1929.

5. Light is the only source of chemical or physical influence which (by its weakness) appears to be directly and positively concerned in the poor productivity of the winter season.

6. So far as I know, these series include the only catches of phytoplankton made in Alaskan waters from late fall through midwinter, and I know of no others of such extent in high latitudes at that season anywhere. For these reasons they have great value as positive records of distribution of organisms at places and seasons not sufficiently investigated. They also have value because of their showing that plankton collecting of some kind can be effectively done under unfavorable conditions of weather and climate.

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